PART TITLE: WVDP WASTE FORM QUALIFICATION REPORT - CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: DOSE RATE

3.9 SPECIFICATION FOR MAXIMUM DOSE RATES[1]*

The canistered waste form shall not exceed a maximum surface (on contact) gamma dose
FC1> **rate of 10^5 rem/hr and a maximum neutron dose rate of 10 rem/hr, at the time of shipment.**

3.9.1 Projections of Dose Rates

The producer shall report in the WQR the expected values and the range of expected variation for both gamma and neutron dose rates indexed to the year 2015. The producer shall describe the method for demonstrating compliance in the WCP.

3.9.2 Dose Rates at Time of Shipment

The producer shall provide in the Storage and Shipping Records either the calculated or measured values for both gamma and neutron dose rates at the time of shipment for each canistered waste form. The producer shall describe the method of compliance in the WCP.

WVDP COMPLIANCE STRATEGY

Projections of gamma dose rates at the surface of high-level waste (HLW) canisters will be made using the Standardized Computer Analysis for Licensing Evaluation (SCALE) system computer codes[2]. Estimation of radionuclide inventory is described in WQR Section 1.2. The SCALE codes provide the sources of neutron and gamma radiation in the canister based on the type and amount of radionuclides present in the canister. The radionuclides estimated in WQR 1.2 to be present in a canister for the years of 1996, 2015, and 3115 will be used to compute dose rates. Dose rates for the year of shipment (not known at present) will be interpolated from the 1996, 2015, and 3115 data.

IMPLEMENTATION

Variations in dose rates may be expected due to changes in the amount of HLW in a canister. The variation of the waste contained in a canister has been estimated in WQR Section 1.2, including waste concentration and canister fill height variabilities. The nominal and high radionuclide content reported in Section 1.2 will be used to estimate the canister surface dose rates. Although the variation in the height of waste glass in a canister does not affect the surface dose rate, the dose rate surrounding the canister will increase.

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* The specification, as provided in Reference (1), is reproduced in boldface print.

Dose Rate Projection

The radionuclide concentrations expected in the canistered waste forms are based on a waste characterization program which included chemical analysis and simulation studies. The total inventory of radioactivity stored in tanks at the WVDP is discussed in WQR Section 1.2. During storage, the radionuclide concentration decreases at a rate determined by their individual half-lives. Most of the fission products decay almost completely within a few hundred years, although the actinides with long half-life remain for thousands of years. The concentration of radionuclides as a function of time have been determined and are listed in WQR Section 1.2.

The gamma dose rates were estimated by two individual modules of the SCALE system, SAS1 and QADS. The results from these calculations are summarized in Table 1 for the WQR 1.2 nominal and high activity canister cases[3]. The calculated neutron dose rates, also listed in Table 1, were calculated using the SAS1 module.[3] The maximum estimated gamma and neutron dose rates for the high radionuclide canister case, 6362 and 0.088 rem per hour, are far below the limits imposed by this Specification.

The SCALE code predictions were validated by comparing the computer estimates to gamma dose rate measurements. These measurements were made at the surface and ten inches from the surface of production canisters. The measured and estimated dose rates for these canistered waste forms (WV 130 and WV 150) are listed in Table 2.[3] This table demonstrates that both the SAS1 and QADS surface dose calculations conservatively over estimate the measured values, giving high confidence that the WVDP production canisters fully conform to this specification.

The waste glass presents two neutron sources, (alpha,n) reactions and spontaneous fissions. These sources are very small and the ^{10}B concentration in the waste glass further reduces the neutron dose rate by absorbing neutrons.

These gamma and neutron production projections yield surface dose rates of approximately 6362 rem/hr and 0.088 rem/hr respectively (indexed to the year 1996). The neutron source term from (α,n) reactions remains fairly constant, but the neutron source from spontaneous fission decreases slightly over the years. This data clearly indicates that the SCALE codes conservatively over estimate the dose rate at the surface of the canistered waste forms, and supports the conclusion that the WVDP production canisters comply with this specification.

Contributions to the dose rate by Bremsstrahlung radiation is negligibly small. The maximum energies of beta particles emitted by ^{137}Cs and ^{90}Sr are 0.51 and 0.54 Mev respectively which are too low to significantly contribute to dose rate. Beta particles emitted by ^{90}Y have a maximum energy of 2.28 Mev. The medium (glass) in which the beta particle traverses consists mainly of low atomic number elements. Approximately 5% of the medium may consist of high atomic number elements (See WQR Section 1.1.1). About 24% of the total radioactivity in a canister comes from ^{90}Y. Hence a rough estimate of the maximum contribution to dose rate from Bremsstrahlung radiation is about 1.2% (24% x 5%) of the total estimated gamma dose. Further, beta particles interact with the medium by processes other than Bremsstrahlung. Hence the actual contribution to dose by high energy beta particles is much smaller than 1.2% and is therefore neglected.

Dose Rates at Time of Shipment to Repository

The calendar year in which the canistered waste will be shipped from West Valley to a repository is still unknown. Since the shipment date is uncertain, the maximum dose rate will be calculated by interpolating the dose rates calculated for 1996, 2015, and 3115.

DOCUMENTATION

The calculated dose rates at the time of shipment for the canistered waste forms will be reported in the Storage and Shipping Records.

Table 1. Canistered Waste Form Surface Dose Estimates for 1996, 2015, and 3115

WQR 1.2 Radionuclide Loading	SAS1 Predicted Gamma Dose Rate rem/Hr	QADS Predicted Gamma Dose Rate rem/Hr	SAS1 Predicted Neutron Dose Rate rem/Hr
1996 Nominal	4226	4178	3.3 E-02
1996 High	6362	6290	8.8 E-02
2015 Nominal	2715	2685	2.8 E-02
2015 High	4094	4047	7.5 E-02
3115 Nominal	1.4 E-03	3.8 E-03	5.0 E-03
3115 High	3.9 E-03	1.1 E-02	1.2 E-02

Table 2. SCALE Code Validation Summary

Canistered Waste Form	Measured Gamma Dose Rate rem/Hr	SAS1 Predicted Gamma Dose Rate rem/Hr	QADS Predicted Gamma Dose Rate rem/Hr
WV 130, Surface	2070	2476	2624
WV 150, Surface	2200	3457	3412
WV 150, 10 inches from surface	1112	1453	1522

REFERENCES

1. Waste Compliance Plan for the West Valley Demonstration Project High-Level
FC1> Waste Form, WVDP-185. |

† 2. "Standardized Computer Analysis for Licensing Evaluation (SCALE)," 1996, Radiation Safety Information Computational Center (RSIC), Oak Ridge, TN.

† 3. WVNS-DP-030, Revision 0, "SCALE Canistered Waste Form Surface Dose Rate Estimate," January 20, 1997.

† These references are required to demonstrate conformance with the WCP compliance strategy.

WVNS RECORD OF REVISION

Rev. No.	Description of Changes	Revision On Page(s)	Dated
0	Original Issue Per Engineering Release #2052	All	3/8/91
1	Per ECN #4240	9,10,12	4/5/91
2	Per ECN #5504	3,5,8-11,14	9/9/92
3	Per ECN #6921 Formerly issued as WQR Section 3.8, Specification for Maximum Dose Rates	All	10/5/93
4	Changed to Project Document per ECN #6990. Document formerly issued as WVNS-WQR-001, Section 3.9.	All	3/22/94
5	Text changes per TRG comments - Reference letter CD:94:0067.	2,5,7,AP-A-1	08/10/94
6	Identification of key references.	7	08/14/96
7	Major change revision to change source code for dose rate estimates.	All	10/30/98
FC1	Updated Specification to be consistent with current revision of WAPS. Deleted revision number and date from Reference 1. No departments are impacted by this change.	1 5	10/03/01

WVNS RECORD OF REVISION CONTINUATION FORM

Rev. No.	Description of Changes	Revision On Page(s)	Dated